UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 7 Examination in Engineering: July 2016

Module Number: CE7203 **Module Name:** Computer Analysis of Structures

[Three Hours]

Answer all questions (Each question carries 15 marks)

All standard notations denote their regular meanings

Q1. A line diagram of proposed steel frame to support a monument is shown in Fig. Q1. The symmetrical frame is rigidly fixed at supports F, G, H, and I, and it is rested on simple supports at A, B, D, and E. The monument is expected to erect at the centre C and which will exert a point load of P on the steel frame. All the members have same section properties and GJ=0.8EI.

(a) Considering symmetry of the steel frame, idealize beam ABC and produce a line diagram indicating all the force components.

[5.0 Marks]

(b) Using matrix stiffness method, find the support moments and reactions on the idealized beam ABC in Part (a). The moment exerted on the beam ABC at point B due to the torsional moment of beams FB and HB is equal to $2GJ\frac{\theta_B}{1.6l}$.

The stiffness matrix for a beam element ignoring axial effect is:

$$[K]=\frac{EI}{L^3}\begin{bmatrix} 12 & 6L & -12 & 6L \\ 6L & 4L^2 & -6L & 2L^2 \\ -12 & -6L & 12 & -6L \\ 6L & 2L^2 & -6L & 4L^2 \end{bmatrix}$$

[10.0 Marks]

Q2. (a) (i) What is the factor which influence the size of structure flexibility matrix?

[1.0 Mark]

(ii) Discuss merits and demerits of matrix method of analysis compare to other methods of structural analysis.

[2.0 Marks]

(b) An idealised truss structure shown in Fig. Q2 is to be used as a one leg of an advertising board supporting structure. The cross sectional area (A) of all the members is 100 mm^2 and Young's modulus (E) is 210 GPa. Using matrix flexibility method, determine member forces and horizontal displacement at Node C. Take flexibility coefficient of a bar element as $f = \frac{L}{AE}$.

[12.0 Marks]

Q3. Pin-jointed 2D truss is pinned support at Node A and roller support at Nodes B and C as shown in Fig Q3. The Young's modulus E = 210 GPa for all three bar elements and cross-sectional area A = $3\sqrt{2} \times 10^{-4}$ m^2 for element (1) and (2), 6×10^{-4} m^2 for element (3). A spring connected to Nodes C and D with stiffness of 12.6×10^3 kN/m. Truss system is subjected to a force 1000 kN at Node B.

a) Find the element stiffness matrix for each element with respect to a selected global coordinate system.

[5.0 Marks]

b) Determine the global stiffness matrix of the system.

[2.5 Marks]

c) Define the boundary condition and loading condition for each node.

[2.5 Marks]

d) Determine the displacements at Node B.

[2.5 Marks]

e) Determine the support reaction at each node.

[2.5 Marks]

(Use the stiffness matrix for a 2D-bar element as shown below.)

$$[k^e] = \frac{EA}{L}\begin{bmatrix} c^2 & cs & -c^2 & -cs \\ cs & s^2 & -cs & -s^2 \\ -c^2 & -cs & c^2 & cs \\ -cs & -s^2 & cs & s^2 \end{bmatrix}$$

where $c = Cos\Theta$, $s = Sin\Theta$ and Θ is the anticlockwise angle at node measured from the global X-axis to the local x-axis of the bar element.

Q4. a) A Beam ABC fixed support at Node A, roller support at Node B and free at Node C as shown in Fig Q4(a). The Young's modulus of the beam is E and second moment of area is I and $EI = 2 \times 10^6$ Nm^2. Consider load applied at Node C as 500 N.

(i) Determine the element stiffness matrix for each element.
(ii) Assemble the global stiffness matrix for the entire system.
(iii) Compute the nodal displacements and rotations.
(iv) Find the reaction forces.

[8.0 Marks]

b) If the beam is loaded with a clockwise moment 1250 Nm at Node B and a uniformly distributed load 600 N/m between A and B as shown in Fig. Q4 (b).

(i) Find the equivalent nodal forces and moments at the three nodes of the beam and draw the resultant on the model.
(ii) Compute the nodal displacements and rotations.
(iii) Find the reaction forces.

[5.0 Marks]

c) Propose possible method to increase the accuracy of the answer in the analysis.

[2.0 Mark]

Ignore the axial effect and use the stiffness matrix for a beam element as given in Q1 (b).

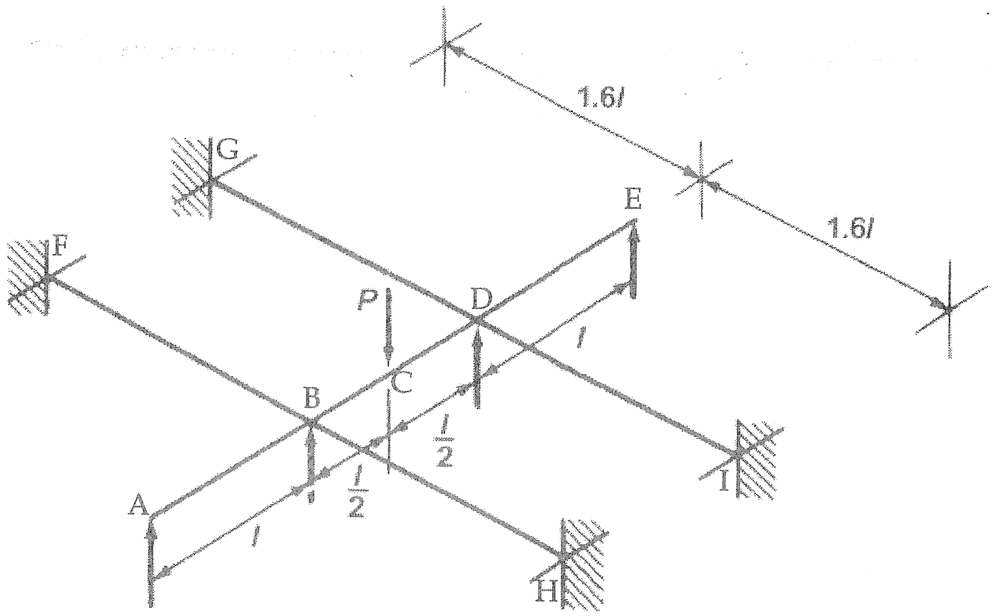

Fig. Q1

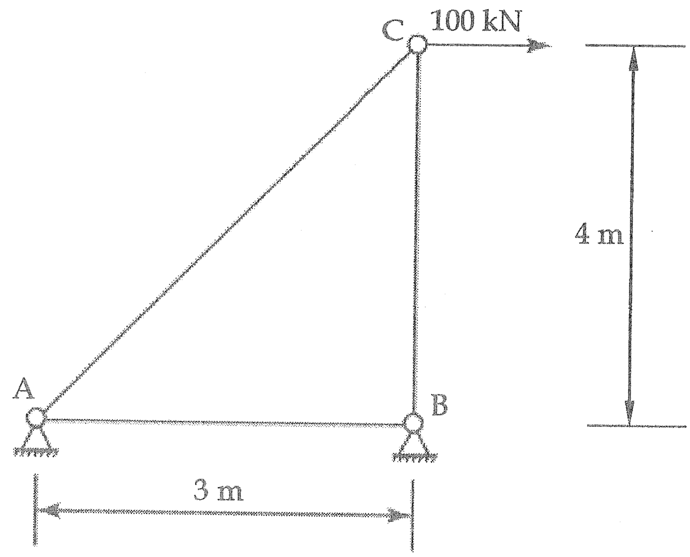

Fig. Q2

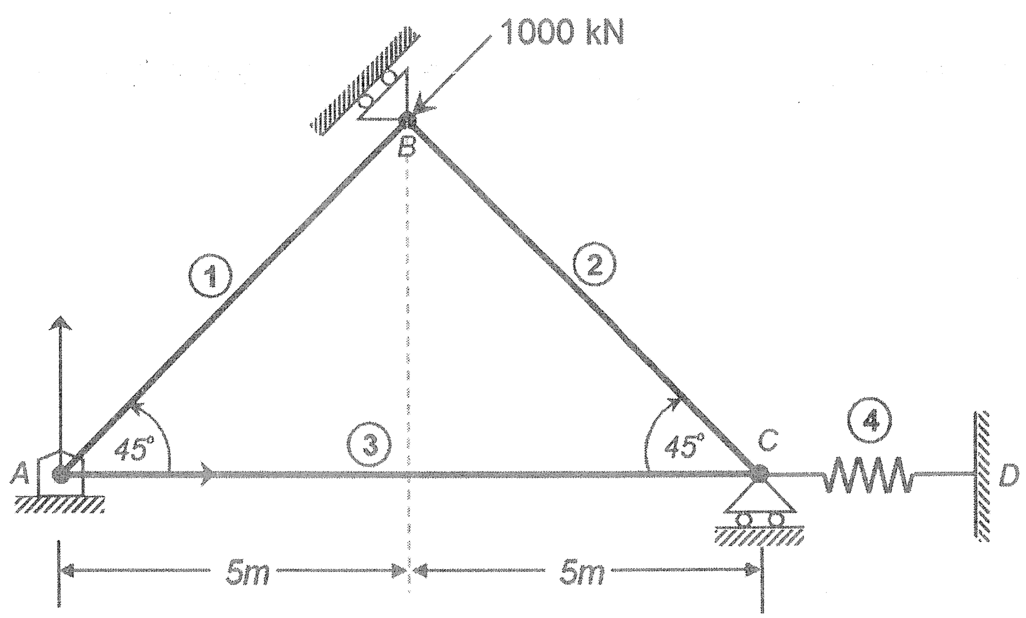

Fig. Q3

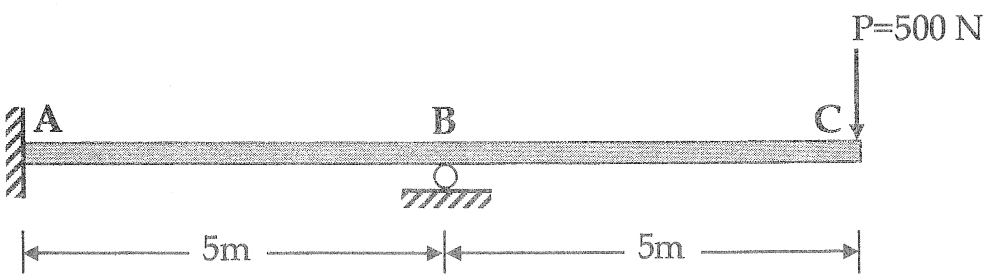

Fig. Q4 (a)

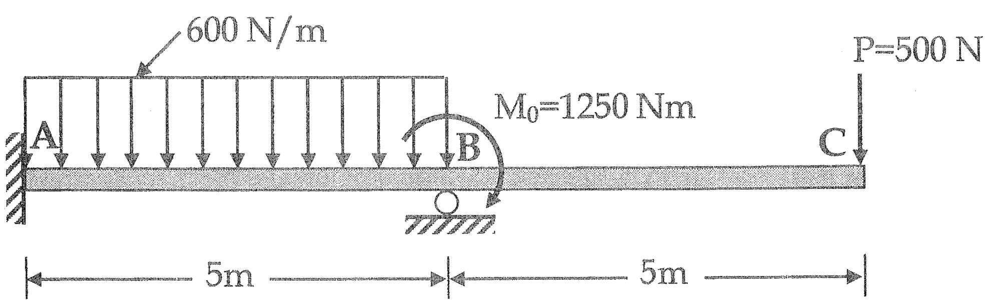

Fig. Q4 (b)